Chapter 17
River Engineering Hydraulic and Channel Stabilization Surveys

17-1. General Scope and Applications

This chapter describes hydrographic survey procedures used in support of the Corps flood control and river engineering missions. These activities include survey support for hydrologic and hydraulic studies, investigation of river stabilization structures, scour surveys around bridges, locks, and dams, and other investigations needed to model physical aspects of river navigation systems (Figure 17-1).

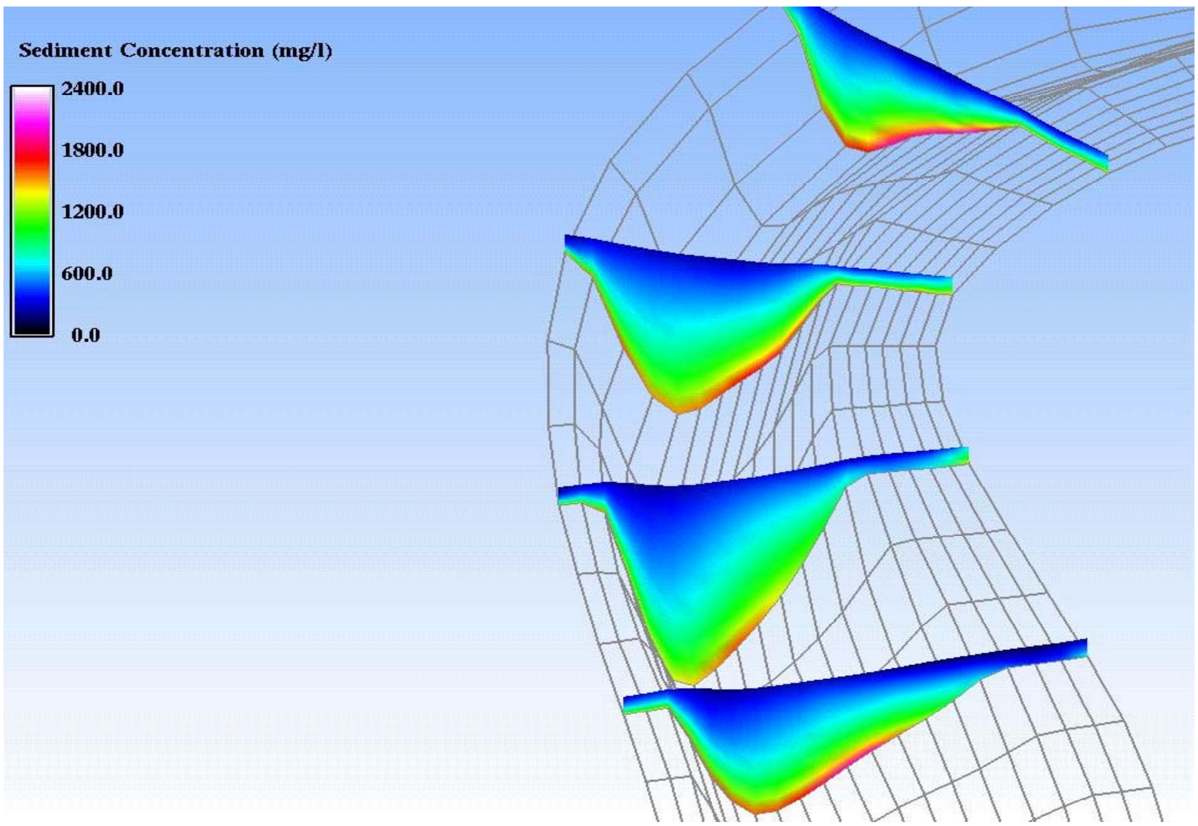


Figure 17-1. Typical multi-dimensional hydraulic and sedimentation model--for modeling flood damage reduction and channel restoration projects

17-2. River Hydraulics Studies

River hydraulic investigations and studies include the evaluations of flow characteristics and physical behavior of rivers--e.g., prediction of stage, discharge, velocity, and sediment transport rates. Basic hydrographic survey data is a critical component of these studies. Other hydraulic studies requiring field survey support may involve the determination of the elevation of dams, spillways, levees, and floodwalls. Hydrographic, topographic, and/or photogrammetric surveys may be required to support hydraulic modeling of floodplains, flood control channel design, navigation modeling, water quality assessment, and environmental impact and assessment analysis. Survey data is incorporated into physical and numerical hydraulic models used for analyzing or predicting the physical processes of a river system. For more detail on hydraulic investigations see EM 1110-2-1416 (River Hydraulics).

a. Hydraulic engineering studies. A variety of hydrologic engineering studies require hydrographic survey support to define the basic models. Some of these studies or models include the HEC/GEO-RAS (River Analysis System), steady flow water surface profiles, unsteady flow simulation, UNET (unsteady flow network hydraulic model), sediment transport modeling, flood inundation modeling, hydraulic flood stage modeling and forecasting, flood inundation modeling and mapping, and flood damage assessment. Hydraulic studies typically require three general data categories: (1) discharge, (2) geometry, and (3) sediment. Hydrographic surveyors may be called upon to obtain basic field information for any of these three categories. Obtaining stream section and adjoining bank and floodplain geometry is by far the most prevalent.

b. Discharge studies. Flood control projects are usually designed for the discharge corresponding to a specific flood frequency (design event) while navigation studies use a discharge for a specific low flow duration or frequency. Discharge data may include measured flows along with frequency, velocity, duration, and depth information. Surface profile elevations are also measured during flood events as an aid in flood routing studies. Water depth and channel cross-section profile is a critical component in computing or predicting discharges.

c. Channel Geometry. Channel geometry derived from hydrographic surveys is required for any hydraulic study. Geometric data include channel and overbank topography, stream alignment, bridge and culvert data, channel roughness information, changes in stream cross-section shape or channel alignment. Hydrographic, photogrammetric, and conventional topographic surveys may be required to fully define a streambed, adjacent banks and floodplains. For movable bed studies, repeat surveys may be needed to evaluate a model's performance in reproducing geometric changes. Thalweg profiles or repetitive hydrographic surveys may be needed for analysis of bed forms and the movement of sand waves through rivers.

17-3. Obtaining Cross-Sections for Hydraulic Studies

Cross-section data are used to determine the conveyance and storage of a river channel and overbank areas. Stream section requirements are defined by the hydraulic engineer or study manager. Required cross-sections are typically plotted on a small-scale map (e.g., USGS quadrangle) of the study area. Cross-section spacing will vary depending on many hydraulic factors associated with the purpose of the hydraulic study. They must be obtained at sufficient intervals to define the flow carrying capacity of the stream and its adjacent floodplain, and at locations where changes occur in discharge, slope, shape, roughness, at locations where levees begin and end, and at hydraulic structures (bridges, weirs, and culverts)--see example layout at Figure 17-2. The type of hydraulic model (e.g., unsteady flow or steady flow) will also dictate cross-section locations. On the Mississippi River system, cross-section spacing varies from 500 ft to 5,000 ft. The width of the section depends on the extent of the floodplain (if any), existence of levees, and other factors. Some cross-sections may be run bank-to-bank in the river with overbank topographic sections run to the top of a levee and into the floodplain. If extensive flood inundation studies are involved, then the cross-section may be extended far out into the floodplain--to the so-called "bluff" line where maximum flood stages would be limited. These lines could extend significant distances on some river systems--5 to 10 miles or more.

a. Mixed survey methods. Obtaining cross-sections of floodplain basins requires a combination of survey methods. Hydrographic surveys performed in the river must be supplemented by conventional surveys in the overbank and flood plain areas. Surveys of the floodplains are usually more efficiently performed using automatic photogrammetric methods whereby a gridded digital elevation model (DEM) is created using standard stereoplotter methods. Recently, airborne LIDAR techniques have been developed to provide DEM models of the floodplain. Airborne methods are limited by vegetation cover, which is usually dense along river banks. Conventional topographic survey methods (e.g., differential leveling, total station) will be required to develop obscured areas near river banks and to set breaklines in the final terrain model.

b. Digital elevation models. Since a variety of survey methods are used to obtain cross-sections, it is important that these independent data sets be accurately consolidated into a database from which cross-sections are generated. The hydrographic cross-sections are typically run over finite lines, as are topographic overbank sections and breaklines. The photogrammetric DEM, however, is typically obtained at a prescribed grid interval (i.e., "post" spacing). The accuracy of these data sets also varies. The topographic survey elevations may be accurate to ± 0.2 ft, the hydrographic surveys to ± 0.5 ft, and the photogrammetric DEM to only ± 2 ft.

c. Digital terrain model. Typically, the hydrographic, topographic, and photogrammetric DEM data sets of the river, banks, levees, and floodplains are combined into a continuous digital terrain model (DTM) in a CADD or GIS database (e.g., design files, Arc-Info). Using this DTM, hydraulic cross-sections are cut at the prescribed orientations--based on the hydrographic cross-section alignment. If full-bottom hydrographic coverage was obtained using multiple transducer or multibeam methods, then more flexibility is available is selecting cross-section alignments and locations for the hydraulic model. If a full, dense DTM of hydrographic and topographic coverage is available, then an unlimited number of hydraulic cross-sections are available--at any desired alignment or spacing. The following mapping specifications are representative of those used in overbank and flood inundation areas on the Upper Mississippi and Missouri Rivers:

(1) Vertical Accuracy Requirement
- 4 ft contour interval
- DEM grid elevation accuracy-- ±1.33 ft
- DTM hard spot elevation accuracy-- ± 0.67 ft

(2) Digital Elevation Model (DEM)
- 5 meter post spacings in flood plain
- add "mass points" on levees … i.e., "Digital Terrain Model (DTM)
- cut in all breaklines manually

d. Deliverables. The cross-sections are converted into the particular hydraulic model format -- e.g., HEC-2/HEC-RAS. Usually the surveyor (or A-E firm) is responsible for delivering the cross-section data in a specified model format. Scopes of work will typically define specifications, lateral coverage (Figure 17-3), format requirements, and deliverables for many of the following items:

- Horizontal Datum -- NAD 27 or NAD 83
- Coordinate grid system -- SPCS or UTM
- Vertical Datum -- NGVD 29, NAVD 83, LWRP 74, IGLD 88
- DEM & DTM breaklines/mass points
- River, River Reach & River Station Identifiers
- Cross-Section cut lines
- Cross-Section surface line
- X-Y coordinates of section end points
- X-Y-Z coordinates for each point on section
- Transformed coordinates to station-elevation format

- Main Channel Bank Station Points
- Left and Right Overbank Lengths
- Stream sections (Plan)
- Stream bank, levee, structure detail & breaklines
- In-channel & overbank flow paths

Geometric cross-section data must be entered in hydraulic models in specific formats. These are fully described in operating manuals for these models--e.g., HEC-RAS River Analysis System User's Manual (HEC CDP-68, 1998).

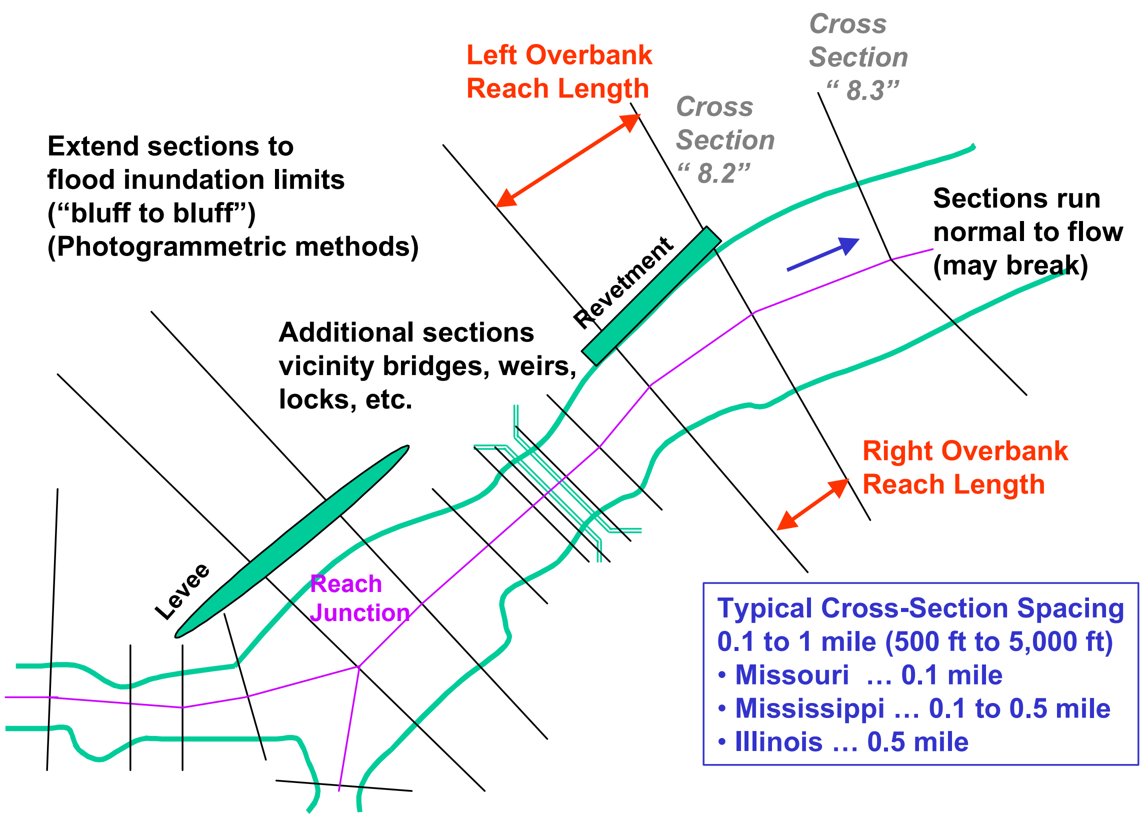


Figure 17-2. Typical cross-section configurations for a HEC-2 or HEC-RAS hydraulic model

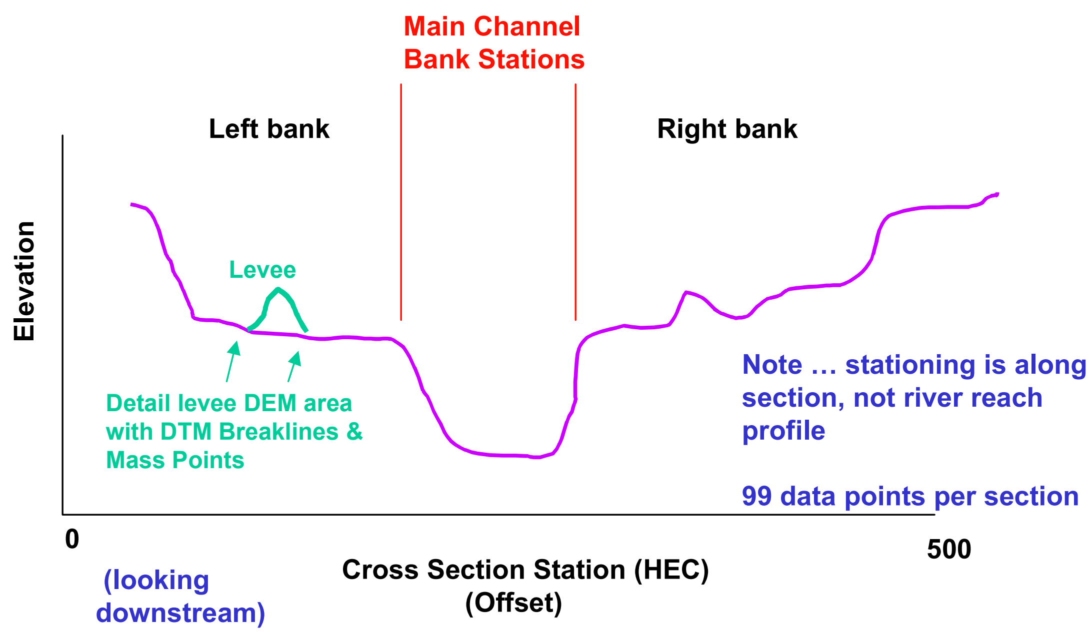


Figure 17-3. Cross-section convention for typical HEC river and floodplain coverage

e. Survey methods. Hydraulic cross-sections are surveyed using similar equipment and methods as standard navigation project surveys. The main difference is that each cross-section is on a different alignment. The end points of each cross-section must be transferred from the map and input into the data acquisition guidance system. The end points coordinated can be digitized from the planning map or scaled by hand. The local SPCS (referenced NAD 27 or NAD 83) should be used. The X-Y coordinate values of the cross-section endpoints can be directly input into line planning software, such as LINE EDITOR spreadsheet in HYPACK MAX (Figure 17-4). A single, unique line is created for every cross-section, with no offsets. The line name should correspond to HEC naming convention. Once this spreadsheet is completed, it can be pulled into the survey guidance program to align individual stream sections.

(1) Small, shallow-draft vessels are used in order to obtain depths as close to the bank as possible. Leadline or sounding poles may be needed in shallow bank areas. Depths are logged using standard data acquisition software. A dense sounding density is not necessary for stream sections in that surface areas will be generalized (smoothed) in the hydraulic modeling programs due to data point per section limitations (99 points). Thus, there is no point to obtain 20 depths/sec when only one depth per 100 ft will end up being used in the overall model.

(2) Vessel positioning accuracy is not critical for hydraulic surveys. USCG DGPS Radiobeacon accuracy is more than adequate; in fact, SPS GPS accuracy (10-20 meters) might be adequate in many cases. Since USCG DGPS is available over much of CONUS, it is recommended for river engineering survey positioning. Code phase USCG DGPS may also be used for horizontal positioning of overbank surveys.

(3) Cross-section elevations are referenced to a consistent vertical datum, such as NGVD 29 or NAVD 88. A dense network of benchmarks must be available along rivers or atop levees in order to set river staffs or gages to control hydrographic surveys. The required density of the vertical network will be a function of the river slope and the distance reliable interpretations can be made between gages. In general, the river surface elevation interpolation accuracy should be kept under $\pm$ 0.5 ft. Gages should be spaced at intervals to maintain this accuracy. Additional reference gages may be required if abrupt changes in slope occur in bends or around control structures.

(4) Bank and short overbank sections may be run at the ends of lines if equipment and personnel are available. Normally, however, overbank sections are performed relative to baselines on the bank or using RTK DGPS techniques from a single reference point. Overbank cross-sections must connect with and be aligned to the hydrographic sections to ensure the full streambed is profiled.

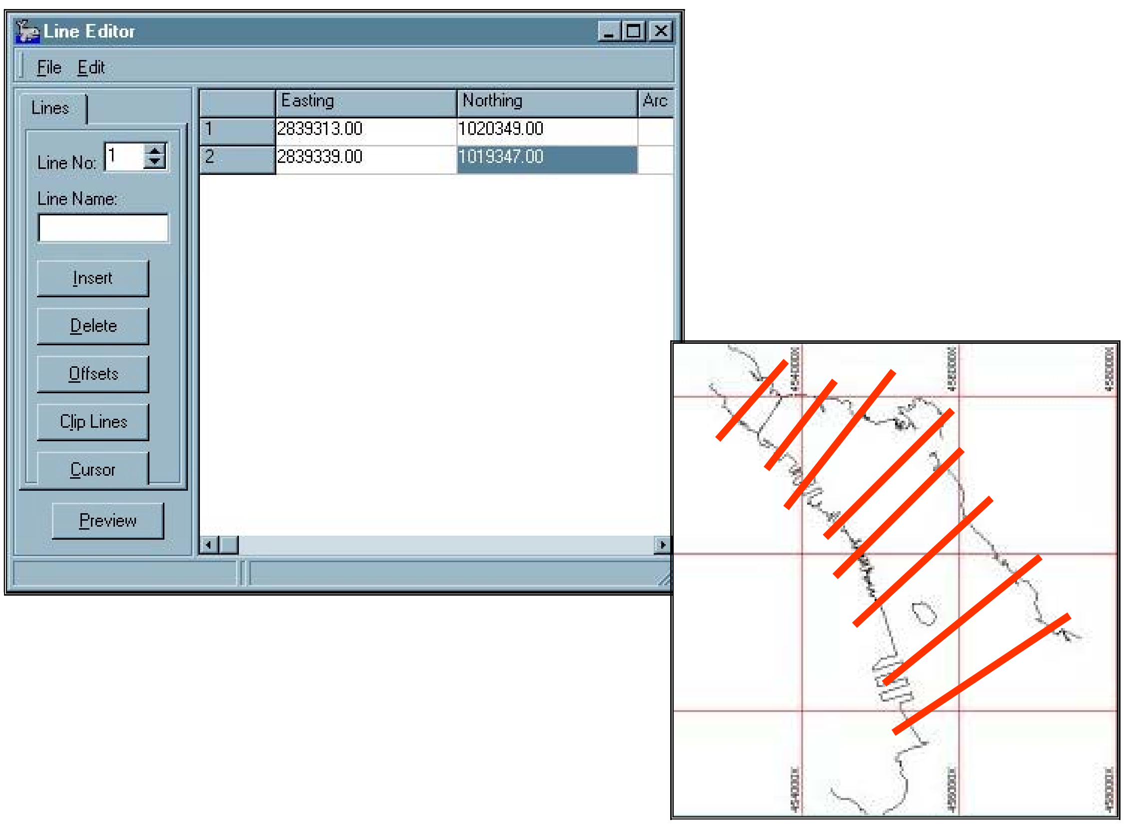


Figure 17-4. Setting up stream sections using HYPACK MAX Line Editor spreadsheet--a separate line is created for each cross-section

17-4. Hydraulic Engineering Guidance on Cross-Section Locations

EM 1110-2-1416 (River Hydraulics) contains detailed guidance for determining the location and spacing of stream cross-sections. Surveyors performing these studies should be aware of the hydraulic considerations that dictated the intended placement and alignment of stream sections. This is important in that field conditions may prevent sections being aligned as desired (due to vegetation, barge blockage, structure blockage, etc.). If new stream alignments or structures are discovered in the field, then additional cross-sections might be required. The field surveyor should make contact with the hydraulic engineer to determine alternate locations or need to include additional sections due to changed field conditions. Often, slight adjustments in section alignments can be made in the field without impacting the hydraulic model. Thus, knowledge of the engineering rationale for locating cross-sections is required by field surveyors in order to make reasonable adjustments or recommend modifications to the project engineer. The following guidelines on locating cross-sections for river hydraulic studies are summarized from EM 1110-2-1416.

a. Cross-section location. Cross-sections should be located at:

- All major breaks in bed profile.
- At minimum and maximum cross-sectional area.
- At points where roughness changes abruptly.
- Closer together in expanding reaches and in bends.
- Closer together in reaches where the conveyance changes greatly as a result of changes in width, depth, or roughness.
- Between cross sections that are radically different in shape, even if the two areas and conveyances are nearly the same.
- Closer together where the lateral distribution of conveyance changes radically with distance.
- Closer together in streams of very low gradient which are significantly nonuniform, because the computations are very sensitive to the effects of local disturbances and/or irregularities.
- At the head and tail of levees.
- At or near control sections, and at shorter intervals immediately upstream from a control (sub-critical flow).
- At tributaries that contribute significantly to the main stem flow. Cross sections should be located immediately upstream and downstream from the confluence on the main stream and immediately upstream on the tributary.
- At regular intervals along reaches of uniform cross section.
- Above, below, and within, bridges.
- Cross sections should be representative of the reaches adjacent to them, and located close enough together to ensure accurate computation of the energy losses. If the average conveyance between cross sections is used to estimate the average energy slope, then the variation of conveyance should be linear between any two adjacent cross sections.
- Cross sections should be located such that the energy gradient, water-surface slope, and bed slope are all as parallel to each other between cross sections as is pragmatic. If any channel feature causes one of these three profiles to curve, break, or not be parallel to the others, the reach should be further subdivided with more sections.
- On large rivers that have average slopes of 2 to 5 feet per mile or less, cross sections within fairly uniform reaches may be taken at intervals of a mile or more.
- More closely spaced cross sections are usually needed to define energy losses in urban areas, where steep slopes are encountered, and on small streams. On small streams with steep slopes it is desirable to take cross sections at intervals of 1/4 mile or less.

- Recommended maximum reach lengths (distances between cross sections) are: (1) 1/2 mile for wide floodplains and slopes less than 2 feet per mile, (2) 1,800 feet for slopes less than 3 feet per mile, and (3) 1,200 feet for slopes greater than 3 feet per mile. In addition, no reach between cross sections should be longer than 75 - 100 times the mean depth for the largest discharge, or about twice the width of the reach. The fall of a reach should be equal to or greater than the larger of 0.5 foot or the velocity head, unless the bed slope is so flat that the above criterion holds. The reach length should be equal to, or less than, the downstream depth for the smallest discharge divided by the bed slope.

b. Additional guidance in EM 1110-2-1416. EM 1110-2-1416 notes the following considerations that are applicable to field surveyors acquiring cross-sectional data.

(1) Cross-sections are run perpendicular to the direction of flow at intervals along the river. The "reach length" is the distance between cross-sections. Flow lines are used to determine the cross-section orientation. The hydraulic engineer will provide these orientations to the surveyor.

(2) The cross-section should be referenced to the stream thalweg and by river mile as measured along the thalweg. From this the reach lengths between sections is computed. End points on the cross-section should be geographically coordinated using the local State Plane Coordinate System.

(3) End station elevations. The maximum elevation of each end of a cross section should be higher than the anticipated maximum water surface elevation.

(4) Local irregularities in bed surface. Local irregularities in the ground surface such as depressions or rises that are not typical of the reach should not be included in the cross-sectional data.

(5) Bent cross sections. A cross section should be laid out on a straight line if possible. However, a cross section should be bent if necessary to keep it perpendicular to the expected flow lines.

(6) Avoid intersection of cross sections. Cross sections must not cross each other. Care must be taken at river bends and tributary junctions to avoid overlap of sections.

(7) Inclusion of channel control structures. Channel control structures such as levees or wing dams should be shown on the cross section, and allowances in cross-sectional areas and wetted perimeters should be made for these structures.

17-5. Cross-Sections Adjacent to Bridges or Culverts

Cross-sections need to be densified near bridges and culverts in order to analyze the flow restrictions caused by these structures. Required sections are shown in Figure 17-5.

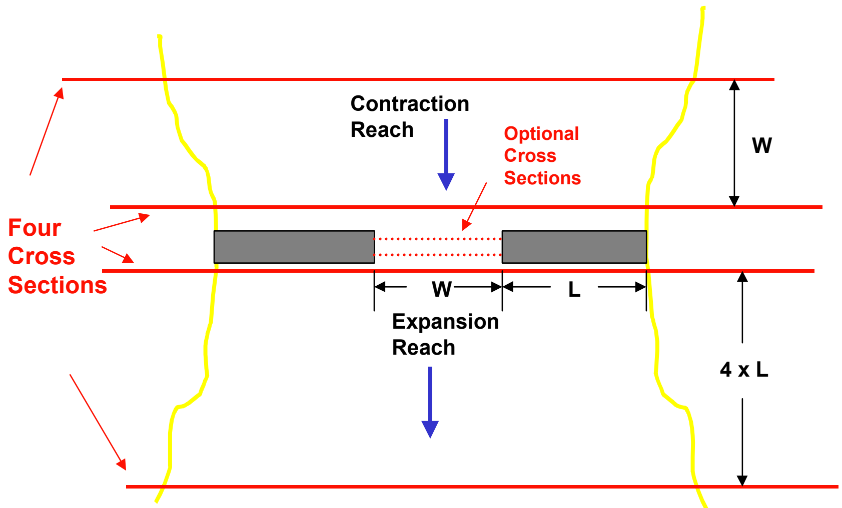


Figure 17-5. Cross-section locations at a bridge or culvert

The downstream section is located such that the flow is not affected by the structure--a distance of about four times the average length of the side constriction caused by the structure abutments. Two cross-sections are run a few feet upstream and downstream of the structure. The upstream section is located slightly further away from the structure--prior to the flow constriction. The upstream section is typically located at a distance equal to the width of the bridge opening or the length of the abutment. Variations in this general scheme exist--see HEC CPD-68, 1998. Other bridge detail is also required, such as dimensions of the bridge deck, abutments, piers, etc. If this information is not available from as-built drawings of the structure, then they will have to be measured as part of the field survey.

a. Navigation locks and dams. Most of the inland navigation projects maintained by the Corps contain navigation locks and dams. The flood profile characteristics in the regulated pools between these structures requires hydraulic modeling. Survey cross-sections may need to be taken more frequently around locks and dams and within the pools due to sediment build up.

b. River control structures. Controls are natural or artificial structures that affect the upstream water surface profile. Control can be dams, rock outcrops, falls, or drop structures. Dikes (i.e., wing dams or jetties) or weirs also impact the flow of water in a channel, depending on the stage. Cross-sections need to be taken on and adjacent to such areas.

c. Levees. Levees prevent floodwaters from entering the floodplain. Levees constrict river flow, resulting in a higher water surface. When levees fail, the protected floodplain becomes available for storage; thus the need for detailed cross-sections over levees and well into the floodplain. Cross-sections are taken at the beginning and end of levees. Floodplain storage can be computed from the DEM model or from cross-sections generated from the DEM surface. In addition, continuous top of levee profile elevations may be required. These can be accurately and efficiently obtained using topographic RTK DGPS survey methods. Levee cross-sections can also be run from the same RTK DGPS set up.

17-6. Required Accuracy of River Cross-Section Data

The accuracy requirements for cross-sections on a river and floodplain are highly dependent on other factors that make up the overall hydraulic prediction model. Other factors, such as Manning's coefficient, have a far more significant impact on the accuracy of computed water surface profiles. In general, horizontal accuracy is not as critical for hydraulic studies as for other navigation surveys. Vertical accuracy is also not as critical, provided there are no systematic errors or blunders in the data. The Hydrologic Engineering Center (HEC) conducted a study of survey accuracy requirements relative to the resultant accuracy on a predicted water surface model--HEC RD 26, 1986. Following are conclusions derived from this 1986 study.

a. For areas with high Manning n-value reliability, the effect of cross-section elevation inaccuracy is insignificant on the computed water profile accuracy. For example, on a river slope of 1 ft/mile, cross-section elevation points accurate to $\pm$ 2.0 ft (1-σ standard error) will affect water surface profile accuracy by less than 0.1 ft. A $\pm$ 2.0 ft elevation accuracy can be easily achieved by most conventional topographic and hydrographic surveying methods. A $\pm$ 2.0 ft (1-σ standard error) can also be obtained by manually digitizing the cross-section directly on a photogrammetric stereo model which has been designed to achieve an equivalent 10 to 12-foot contour interval standard--i.e., flown at an altitude that results in a negative scale of 1 inch = 3,333 to 4,000 ft.

b. For cross-sections developed by photogrammetric methods (i.e., a standard HEC cross-sectional DTM is directly developed by an operator on the stereo plotter) there is no significant impact on water surface profile accuracies between stereo models designed for 2-ft ($\pm$ 0.3 ft 1-σ) and 5-ft ($\pm$ 0.8 ft 1-σ) contour accuracies--the accuracy of the computed water surface profile is not significantly improved by using the presumed more accurate 2-ft contour standard. For areas with highly reliable n-values, there is no significant difference on the surface profile's accuracy between 2-ft and 10-ft ($\pm$ 1.7 ft 1-σ) contour mapping accuracies.

c. Cross-section elevations digitized directly from photogrammetric stereo models (i.e., "spot elevations" in 1986 study) are more accurate than cross-section elevations indirectly derived (e.g., scaled--manually or electronically) from topographic contour maps. Thus cross-sections indirectly derived from an existing contour map, or from a digital terrain model (DTM)--which has been constructed using triangulated irregular networks based on a gridded digital elevation model (DEM) and auxiliary breaklines--will not be as accurate as cross-sections directly digitized on the stereo model. (The 1986 study did not assess the effect of DEM "post" spacing density on indirect elevation accuracy since these techniques were not commonly used at that time. In addition, the old manual process of generating cross-sections by scaling intersecting contours is more rarely used given elevations can be obtained directly from DEM/DTM/TIN models).

d. Mean water surface profile errors resulting from less reliable estimates of Manning's coefficient are several times those resulting from survey measurement errors alone.

e. Error prediction equations (in the 1986 study) can be used to determine the mapping technique and accuracy needed to achieve a desired computed profile accuracy. Conversely, the error prediction equations can be solved for required digital elevation point accuracy given a specified mean water surface profile accuracy and other hydrologic factors.

f. Assuming a mean water surface profile modeling accuracy requirement of between 0.2 ft and 0.5 ft, a reliably known n-value, and low gradient stream slope, the required digital elevation accuracy along a cross-section is needed to no better than $\pm$ 2.2 ft. This accuracy level can be easily achieved by conventional (terrestrial) topographic surveying methods and hydrographic surveying methods. It also could be obtained by digitizing cross-section elevation points from a photogrammetric stereo model designed to meet a 10-ft contour interval accuracy standard--a low accuracy product.

g. If cross-section elevation points are indirectly derived from a newly mapped DTM (DEM) surface, then the point accuracy of the DEM grid (posts) must be better than that needed for directly digitized cross-section points. This increased accuracy will be a function of the "post" spacing (density) and local terrain gradient. Accuracy differences will not be significant in low gradient plains regardless of the post spacing density. Overall, directly observed cross-sections should be obtained in lieu of indirect methods.

h. In low gradient flood plains, cross-sections may be derived using indirect DEM/DTM/TIN model methods. DEM post-spacing should be variable and a function of the (1) required point accuracy, and (2) average terrain gradient. For example, given ± 2 ft required cross-section point elevation accuracy and a 2% gradient, a 50-ft DEM post spacing would be recommended. Breaklines are added at critical points, e.g., tops/bases of levees, roads, etc.----resulting in an "irregular network of mass points with breaklines."

i. In high-gradient areas (e.g., levees, road/rail embankments, etc.), photogrammetric cross-sections should be directly digitized from the stereo model. DEM/DTM derived cross-sections would not be recommended due to the dense post spacing that would be required to achieve the equivalent accuracy.

j. Digital elevation data from USGS quadrangle DEMs may be sufficiently accurate for cross-sectional data outside Federal levees--provided these maps are relatively current. Any additional mapping in these potential overbank areas could be performed to standard 10-ft contour interval standards.

k. Levee, roadways, railroads, and other similar flood controlling embankments should be profiled to around ± 0.5 ft accuracy. It will likely be more cost-effective to perform this profiling photogrammetrically rather than using DGPS/RTK (carrier phase) techniques--if concurrent mapping/cross-sections are being performed over the same area. On levees with excessive vegetation, ground-based cross-sections will be needed to supplement the photogrammetric sections and/or profiles.

l. Inundation mapping accuracy requirements are independent from water surface profile accuracy requirements. No photogrammetric mapping technique will cost-effectively measure ± 0.1 to ± 0.2-foot first-floor elevation accuracy throughout the study region. However, RTK DGPS methods will not normally reach these accuracy levels either.

m. Inundation mapping accuracy requirements will depend on the flood plain gradient, land use, and control features (embankments, etc.).

n. Unnecessary or unanalyzed topographic mapping accuracy specifications will significantly deplete existing mapping resources as mapping costs vary exponentially with the vertical accuracy requirement.

o. A ± 2 ft elevation data point standard error may now be achievable with Airborne GPS (ABGPS) control and LIDAR topographic mapping techniques-- i.e., no ground photo control points required. If this is achievable, significant cost savings could result. Thus, use of ABGPS in less critical overbank floodplain might be considered.

17-7. Surveys of Navigable Rivers, Locks and Dams, and River Stabilization Structures

The Corps performs numerous hydrographic surveys throughout its inland navigation system. Many of these surveys involve underwater mapping and investigation of channel reaches, crossings, cutoffs, and bends, sediment movement and deposition, scour in bends, channel stabilization structures, and training structures such as spur dikes, longitudinal dikes, vane dikes, and closure dikes. Investigative hydrographic surveys are also performed around the approaches, guide walls, guard walls, and lock walls in navigation locks. Such surveys are used for planning and design of improvements to these structures. Details on these requirements can be found in ER 1110-2-1458 (Hydraulic Design of Shallow Draft Navigation Projects) and EM 1110-2-1611 (Layout and Design of Shallow Draft Waterways).

a. Survey methods. Due to the variety of projects surveyed, different hydrographic survey techniques are used. Not all river structures are fully submerged, requiring combined hydrographic and topographic survey methods. Fully submerged structures can be mapped using all the acoustic techniques covered in this manual, i.e., single beam, multiple transducer, multibeam, or side scan. Recently, multibeam surveys have proven useful in detailing underwater structures, such as locks and dams, weirs, dikes, and levee revetments. The following paragraphs contain examples of surveys of various river navigation and stabilization projects.

Figure 17-6. MV Boyer (St. Louis District) -- used for river engineering surveys and investigations on the Middle and Lower Mississippi River

b. St. Louis District MV Boyer. The Mississippi Valley Division (St. Louis District) uses the MV Boyer for river engineering surveys and investigations on the Middle and Lower Mississippi River (Figure 17-6). This 26-ft vessel is equipped with twin 250 HP Yamaha outboards and is outfitted with the equipment listed below. The trailerable vessel has the ability to map underwater features of most flood control and river stabilization structures in the Mississippi River. Its on board data processing equipment provides a "field-finish" capability, enabling same- or next-day delivery of edited data sets to requesting districts in the Mississippi Valley Division.

- Isis Sonar Data Acquisition and Processing System (Triton Elics, Inc.)
- SeaBat 8101 240 kHz Multibeam Bathymetric and Sidescan Imaging Sonar (Reson, Inc.)
- HYPACK and HYSWEEP software (Coastal Oceanographics)
- Position Orientation System with a Trimble Differential GPS and Inertial Block to collect Position and Heave, Pitch, Roll and Heading Corrections (TSS-UK Ltd.)
- 300 kHz, 600 kHz and 1200 kHz Acoustic Doppler Current Profiler (RD Instruments)
- 200 kHz Single Beam Echo Sounder with Hull Mounted Transducer (Innerspace Technology)
- Sound Velocity Probe with Salinity and Temperature Recorder (Marimatech)
- DT 5000 120 kHz Dual Beam System for Locating Fish or Biomass (BioSonics)
- DT 4000 200 kHz Dual Beam System for Identifying Bottom Classification (BioSonics)
- RoxAnn to Identify Bed Material Types (Marine Microsystems Limited)
- Triton Isis Built Computer (700 MHz CPU, 512 MB RAM, 27 GIG Hard Drive, Dual Monitors, CD-RW, 250 MB Zip)

c. Bendway weir and dike surveys. As shown in Figure 17-7, multibeam systems can be effectively used to provide detailed surveys of bendway weirs. Periodic surveys can be performed to monitor sediment erosion and deposition in the bends and adjacent to the weirs. Figure 17-8 depicts a dike failure picked up during a multibeam survey of the structure.

Figure 17-7. Bendway weir multibeam surveys (St. Louis District)

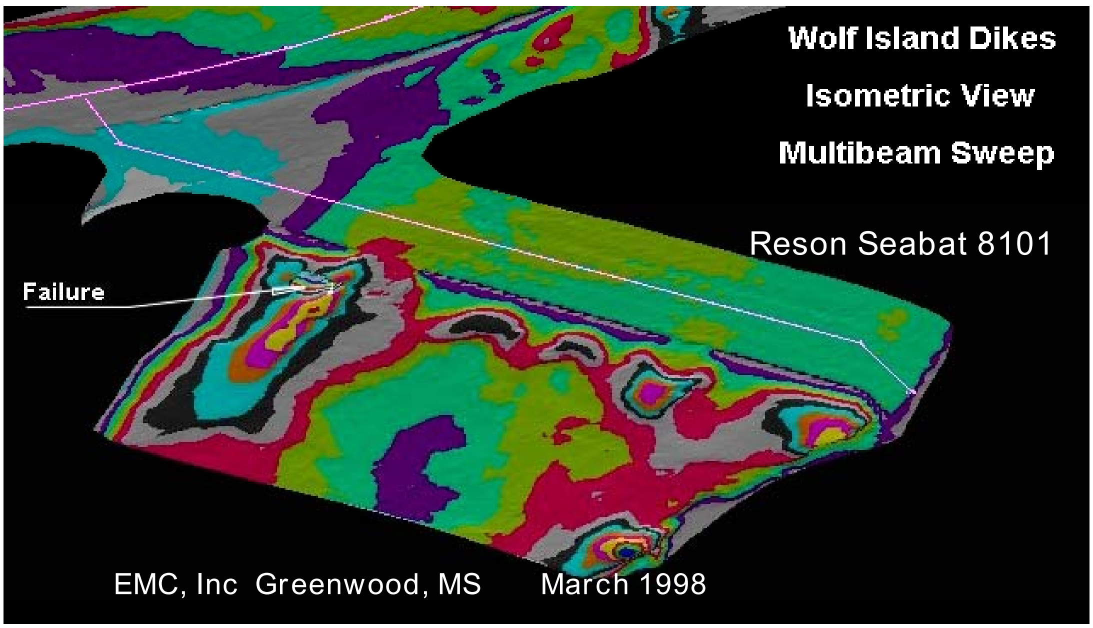
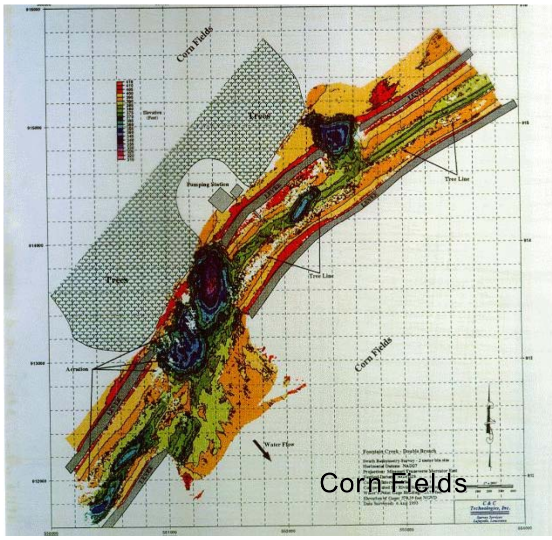
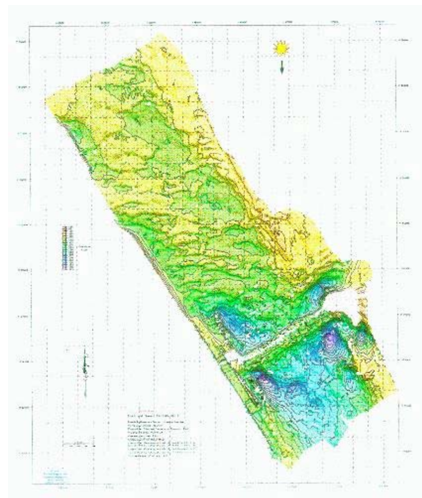


Figure 17-8. Multibeam surveys of Wolf Island Dikes--Cairo, IL (Memphis District)

d. Levee breech surveys. Figure 17-9 illustrates the use of multibeam systems during the Mississippi River flood of 1993. During high water stages in which levees were overtopped, breeches were located and mapped, allowing repair estimates to be made. Figure 17-9 also depicts a multibeam survey performed over Lock and Dam 25 when much of the structure was covered during high water.



Fountain Creek -- Double Levee Breach
6 Aug 93



Mississippi Lock/Dam 25
17 Aug 93 (Mile 241.5)

Figure 17-9. Levee breech and lock & dam surveys during 1993 flood (JE Chance & Associates for St. Louis District)

e. Mississippi River sand wave mapping. Multibeam systems are used in the Corps to map sand wave movement and elevations in the Mississippi River. A typical survey is shown in Figure 17-10.

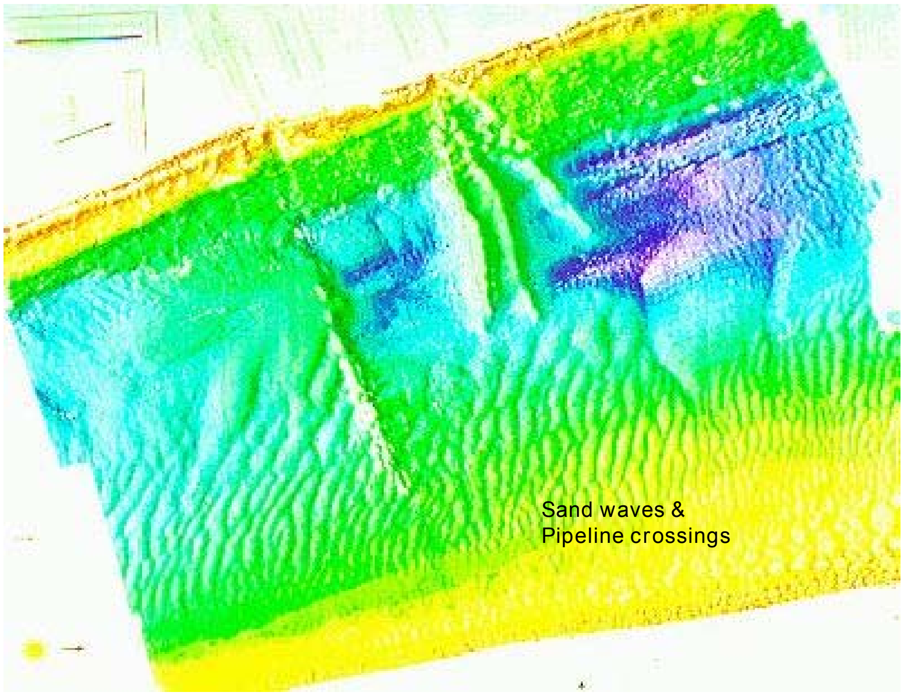


Figure 17-10. Lower Mississippi sand wave surveys using multibeam

f. Sheet pile wall surveys. Figure 17-11 depicts a underwater survey of a sheet pile wall performed as part of a wave surge study.

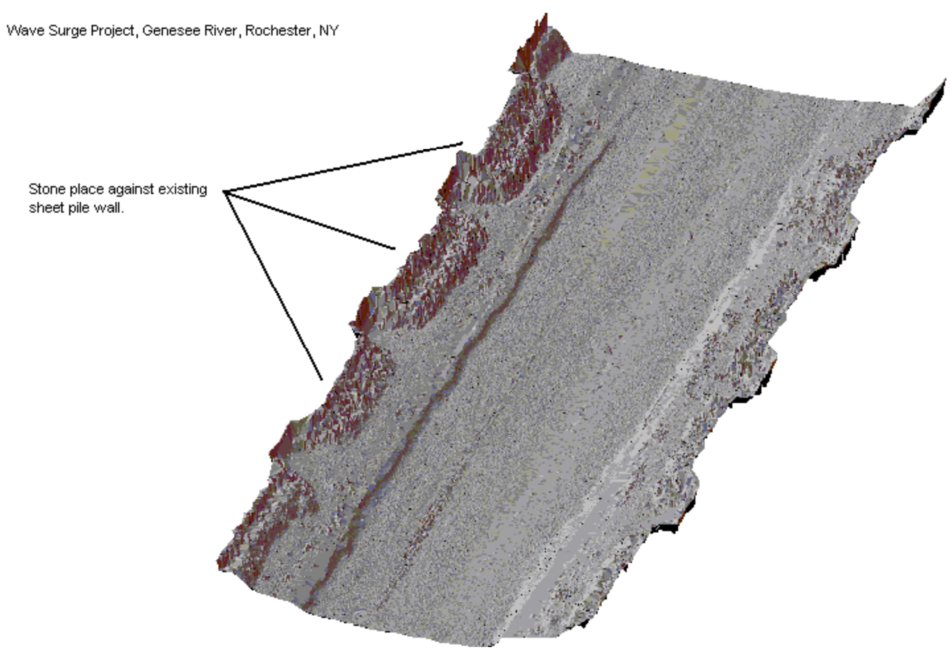


Figure 17-11. Sheet pile wall multibeam surveys. Genesee River, Rochester, NY (Buffalo District)

g. Bridge scour surveys. Figure 17-12 shows a bridge scour survey performed using a single beam transducer. The survey was done for the New Your City Triborough Bridge and Tunnel Authority by Lichtenstein Engineering using Innerspace Technology data collection equipment and software. The vessel was positioned with a total station. Processing and plotting was done on AutoCad.

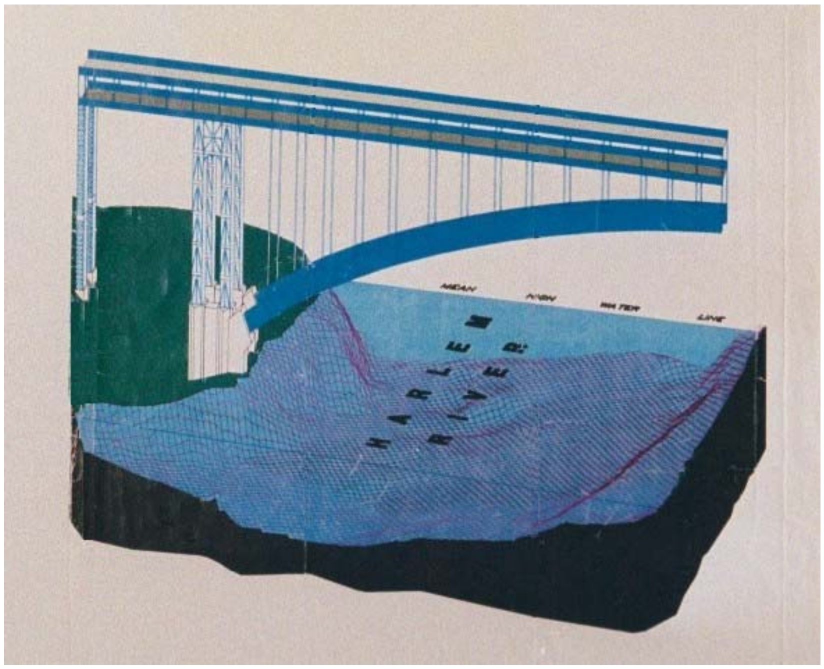


Figure 17-12. Triborough Bridge scour survey (Lichtenstein Engineering and Innerspace Technology)

h. Lock and dam surveys. Figure 17-13 depicts a multibeam survey of Columbia Lock and Dam to locate sunken barges behind the spillway. The survey was performed by EMC, Inc. of Greenwood, MS.

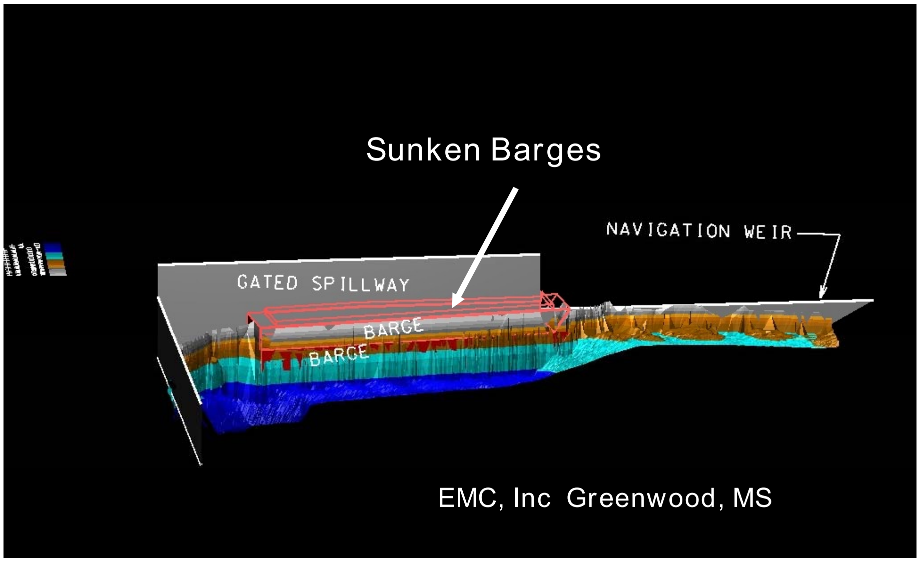


Figure 17-13. Columbia Lock & Dam (Vicksburg District)

i. Lock approach surveys. Figures 17-14, 17-15, and 17-16 depict multibeam surveys of approaches to Corps navigation locks. Small bin sizes provide details of the approach wall pilings, baffle blocks, and scour areas in the approaches to the chambers.

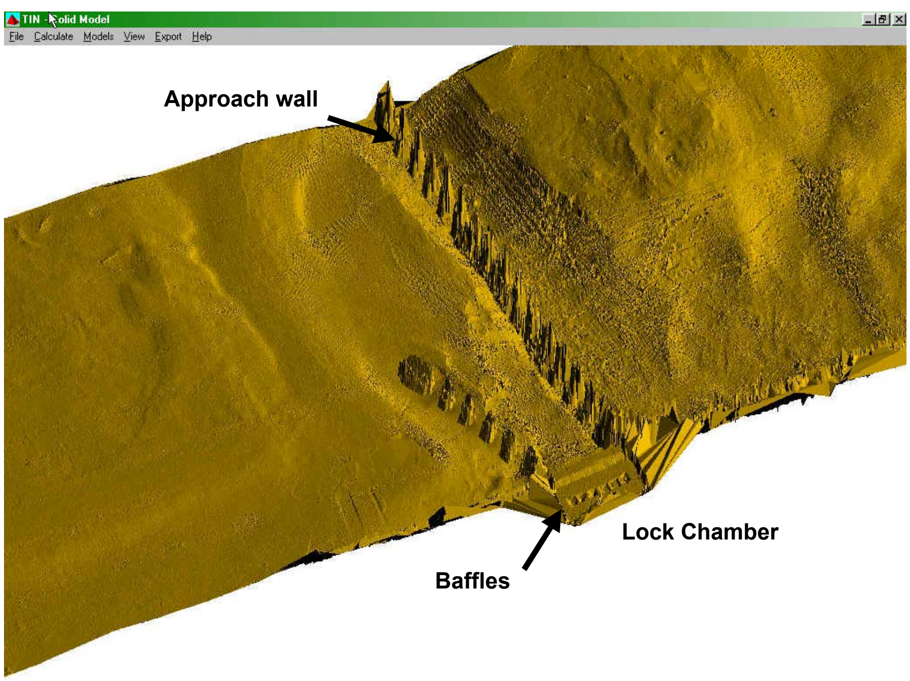


Figure 17-14. 3-D terrain model from multibeam survey of approaches to Woodruff Lock and Dam (Mobile District--EMC, Inc.)

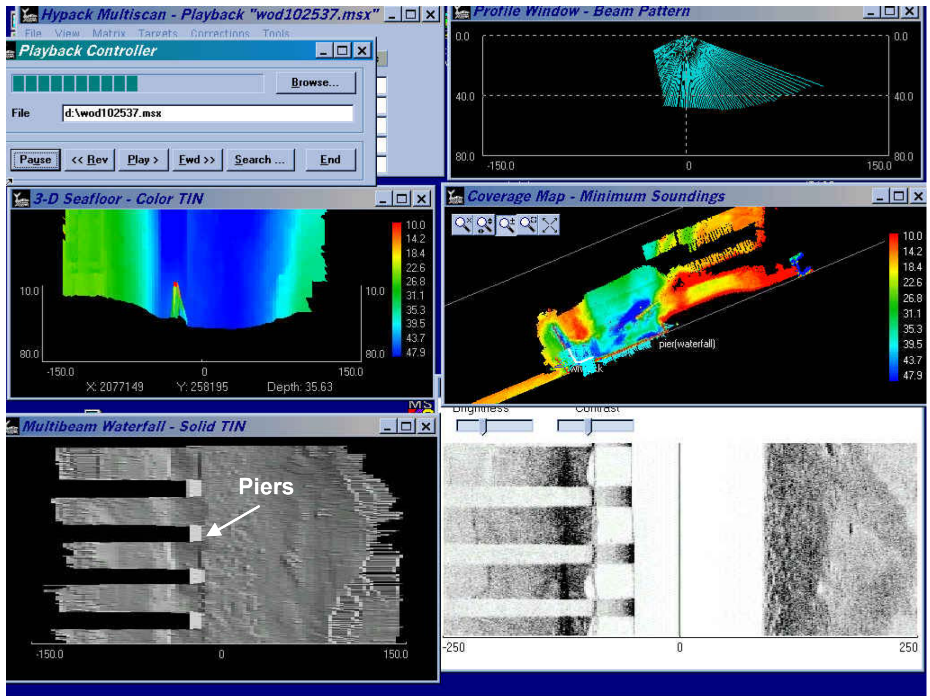


Figure 17-15. Multibeam screen display of approach wall piers. Topographic model (lower left) and side scan sonar (lower right) depicts imagery between pilings. Woodruff Lock and Dam (Mobile District--EMC, Inc.)

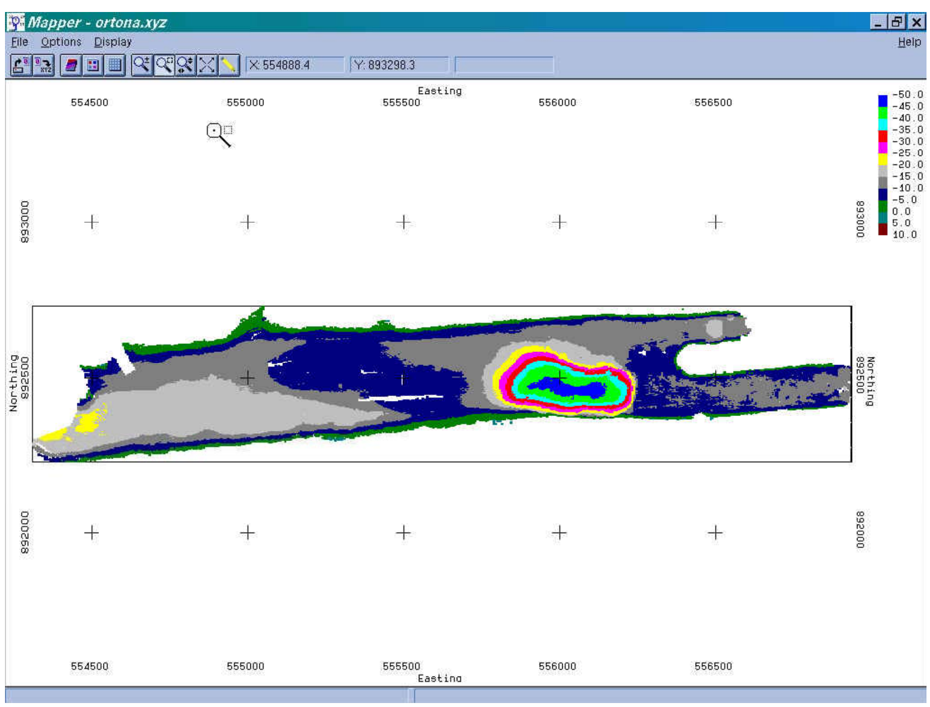


Figure 17-16. Deep scour hole vicinity approaches to Ortona Lock (EMC, Inc.)

j. Revetment surveys with side scanning multibeam systems. Multibeam transducers can be tilted upward to detail revetments, bridge piers, fenders, pilings, lock guide walls, breakwaters, jetties, and other structures. Topographic coverage up to near the water's edge is possible. In deeper draft areas, coverage under moored barges is feasible. The sketch at Figure 17-17 illustrates side viewing multibeam coverage on a rip rap embankment.

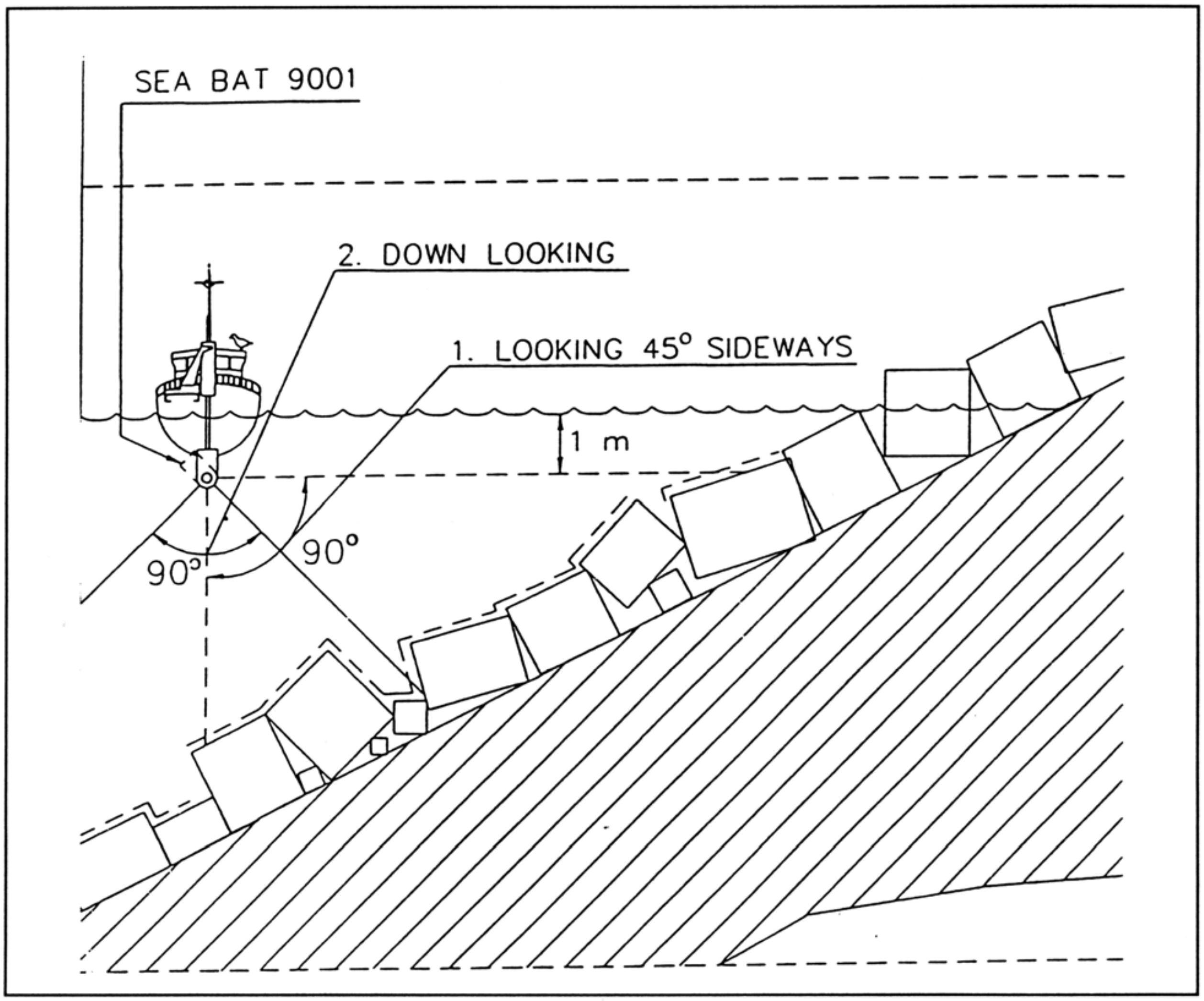


Figure 17-17. Tilting multibeam transducer head for surveying lateral structures (Reson, Inc.)

k. Revetment construction and maintenance. Revetment grading, construction, and maintenance projects require a variety of surveys. During placement of articulated concrete mats (Figure 17-18) control surveys are needed to accurately align the sinking plant equipment. Subsequent hydrographic condition surveys are periodically performed to assess the condition of the concrete mats.

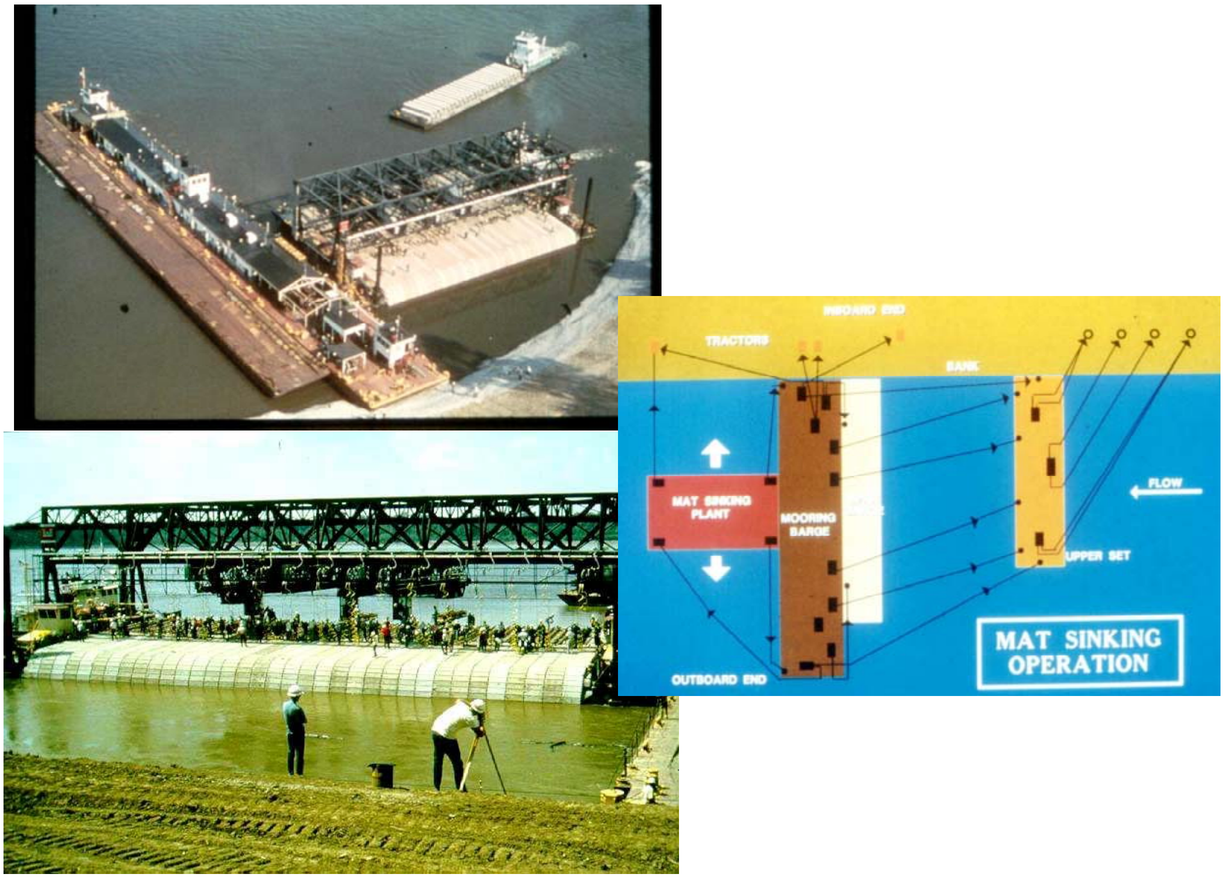


Figure 17-18. Alignment surveys for placement of concrete mats along Mississippi River revetments (Memphis and Vicksburg Districts)

17-8. References

HEC RD 26 1986
Hydrologic Engineering Center (HEC) Research Document 26 (HEC RD 26*), Accuracy of Computed Water Surface Profiles,* 1986, incl. Supplemental volumes

HEC CPD-68 1998
Hydrologic Engineering Center (HEC) CPD-68, *HEC-RAS River Analysis System User's Manual*, Version 2.2, September 1998

Note that references to HQUSACE publications are listed in Appendix A.

17-9. Mandatory Requirements

There are no mandatory requirements in this chapter.